Survey on the Assurance of Programmable Logic at NASA Centers

Note: Please return completed questionnaires directly to the contact person listed at the end of this survey. Partial submissions will be gladly accepted.

Purpose

Programmable Logic devices are becoming common within NASA projects and facilities. Programmable Logic Controllers often replace older control systems. Programmable Logic chips, such as FPGAs, are used to create custom capabilities within instrumentation. While essentially "hardware" devices, they are programmed like software. This hybrid aspect of Programmable Logic may not be fully addressed when the devices are assured.

This questionnaire will provide a information on how Programmable Logic devices are assured for functionality, reliability, and safety. A cross-section of all Centers is required to provide accurate NASA-wide information.

The results of this questionnaire will be used as guidance for the creation of an Assurance Guidebook for Programmable Logic devices. Summaries of the information may be presented at technical conferences or within technical papers.

This questionnaire is part of an ongoing research project funded by the NASA IV&V Center through a Center Initiative. The Principal Investigator (PI) has produced this survey to obtain information on Programmable Logic usage throughout NASA and the processes used to assure those devices.

Background

Until recently, there was a reasonably clear distinction between hardware and software. Hardware was the pieces-parts: transistors, resistors, integrated circuits, etc. Software ran on the hardware (operating systems, applications programs) or resided *inside* the hardware (firmware).

Programmable logic blurs the lines between hardware and software. While the result is "hardware", they use a programming language to express the hardware relationships (like "software"). Two distinct categories of devices are included within the broad category of Programmable Logic: Programmable Logic Controllers (PLCs) and Programmable Logic Devices (PLDs).

A PLC is a special purpose computer having a central processing unit (CPU), power supply, a programming panel and/or interface to a programming system, inputs, and outputs. A PLC should also provide the capability to support remote I/O, special purpose I/O, I/O housings, connection, cables, additional power supplies, communication boards etc. A PLC is sometimes called a "programmable controller".

PLCs are used to control other equipment, such as production-line instrumentation or wind tunnels. They are programmed to perform their control function, usually in a ladder diagramming language. Conventional programming languages, such as BASIC, and other textual or graphical languages are becoming more commonly used in PLC programming.

PLDs are defined as devices with configurable logic gates and flip-flops, linked together with programmable interconnects. Memory cells control and define the function that the logic performs and how the logic gates are interconnected. Circuitry is developed in a programming language (such as VHDL [Very High Speed Integrated Circuit (VHSIC) Hardware Description Language] or Verilog), run on a simulator, compiled, and downloaded to the programmable device (PLDs). Simple PLDs have fewer than 500 logic gates while complex PLDs, such as CPLDs and FPGAs, can have 500 to more than 100,000 logic gates. While the resulting device is "hardware", the process of programming or designing it is "software". Some versions of programmable devices can even be changed "on the fly", such as CPLDs or FPGAs, though others, such as application specific integrate circuit (ASIC) devices, can only be programmed externally.

The variety of PLDs include:

- Field Programmable Gate Array (FPGA)
- PAL (Programmable Array Logic)
- GAL (Generic Array Logic)
- PLA (Programmable Logic Array)
- EPLD (Erasable Programmable Logic Device)
- EEPLD (Electrically-Erasable Programmable Logic Device)
- MAX (Multiple Array matrix)

Assurance is defined as "those activities that demonstrate the conformance of a product or process to a specified criteria (such as a functional requirement or a standard)." [from NASA Software Assurance Standard, NASA-STD-2201-93] Specific assurance activities vary with the discipline performing the assurance function. Activities usually include testing, documentation review (e.g. plans, requirements, schematics, software design diagrams), and process audits.

Confidentiality

Any personal information gathered as a direct or indirect result of this questionnaire will remain confidential. Summary information from the survey will not identify any individual, project, program, or facility, unless permission to do so is granted. Providing personal information is not necessary to complete the questionnaire.

Contact information is requested from those who are willing to be interviewed regarding their assurance of Programmable Logic devices.

Instructions

Please complete this questionnaire if you are a member of an Assurance organization at your Center. Assurance personnel who are contractors are encouraged to reply.

Please feel free to add to, change, or otherwise alter the survey format to convey the information you wish to express. Complete as much of the questionnaire as is appropriate for your level of involvement with Programmable Logic. Feel free to add comments or additional information.

You may reply in any format by contacting Kalynnda Berens via email at **Kalynnda.Berens@grc.nasa.gov**. Further contact information can be found on the last page of this questionnaire.

Questions

1. General Information

NASA Center _____

Organization Code _____

Contractor? __ No __ Yes Company: _____

Assurance Role _____

2. Have any of the projects, programs, or facilities (P/P/F) you currently support, or have supported in the past, used Programmable Logic (as defined in the **Background** section)? __ Yes __ No

If yes, answer the following questions. Assume they apply only to P/P/F that you support. If no, skip to question 6.

3. Estimate the number of projects, programs or facilities that use Programmable Logic: _____

4. Which of the following types of Programmable Logic were used?

__ Programmable Logic Controller (PLC)
__ Field Programmable Gate Array (FPGA)
__ Programmable Array Logic (PAL)
__ Generic Array Logic (GAL)
__ Programmable Logic Array (PLA)
__ Erasable Programmable Logic Device (EPLD)
__ Multiple Array Matrix (MAX)
__ Electrically-Erasable Programmable Logic Device (EEPLD)
__ Complex Programmable Logic Device (CPLD)
__ System-on-a-chip (SoC)
__ Application Specific Integrated Circuit (ASIC)
__ Other _____

5. Were any Programmable Logic devices involved in safety-critical aspects? For example, were any used to control safety-critical hardware? __ Yes __ No

If yes, please describe one or more situations where the Programmable Logic had safety implications:

_____

_____

_____

6. For Programmable Logic at your Center, what assurance activities are performed and by whom?

Activity	Project	Software Assurance Group	Other Assurance Group	Other (specify)
Testing of Programmable Logic (PL) device				
Test witnessing				
Code review (formal or informal)				
Development process audit				
Configuration management audit				
Witness PL “burning” (physical programming) and installation				
Functional Configuration Audit				
Physical Configuration Audit				
Version Description Document or equivalent				
Safety Verifications				

7. Are you aware of any standards for the design, programming, verification, or safety of Programmable Logic devices? __ Yes __ No

If yes, please list the standards:

_____

_____

8. Is the Software Assurance group at your Center involved in Programmable Logic safety-related activities for

Flight Projects	__ Yes	__ No
Non-flight experiments	__ Yes	__ No
Other projects	__ Yes	__ No
Facilities	__ Yes	__ No
Other programs	__ Yes	__ No

Please add any additional comments of safety activities for Programmable Logic:

_____

_____

_____

9. What is your level of experience with Programmable Logic (PL):

__ Know very little about PL
__ Basic knowledge of PL
__ Advanced knowledge of PL
__ Exposure to PL programming
__ Have Programmed PL devices

10. For several projects, programs, or facilities (P/P/F) you support who use Programmable Logic, please describe the following:

- Programmable Logic device(s) used
- The purpose the PL was used for
- How the PL was assured.

Include as many P/P/F as you wish.

Personal Information

If you are willing to be contacted for follow-up questions, please provide contact information below:

Your Name: _____

Email: _____

Phone: _____ (optional)

Preferred contact method: __ Email __ Phone __ Other: _____

If you know someone who has knowledge of how Programmable Logic is assured within NASA, please send them a copy of this questionnaire, or provide contact information:

Name of Contact: _____

Organization: _____

Email: _____

Phone: _____ (optional)

Survey Questionnaire Return Information

Surveys can be returned via email to **Kalynnda.Berens@grc.nasa.gov**.
Due to NASA security regulations, an address for mailing hardcopies cannot be provided in this form. Please contact the researcher via email or phone to obtain a mailing address.

For further information, to convey answers verbally, or to discuss any of the questions in more detail, please contact the researcher directly.

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